Proposed 5D 6D Muon Cooling Experiment at Fermilab

Andreas Jansson
Muon Collider Task Force

MCTF charge

To: Vladimir Shiltsev and Steve Geer

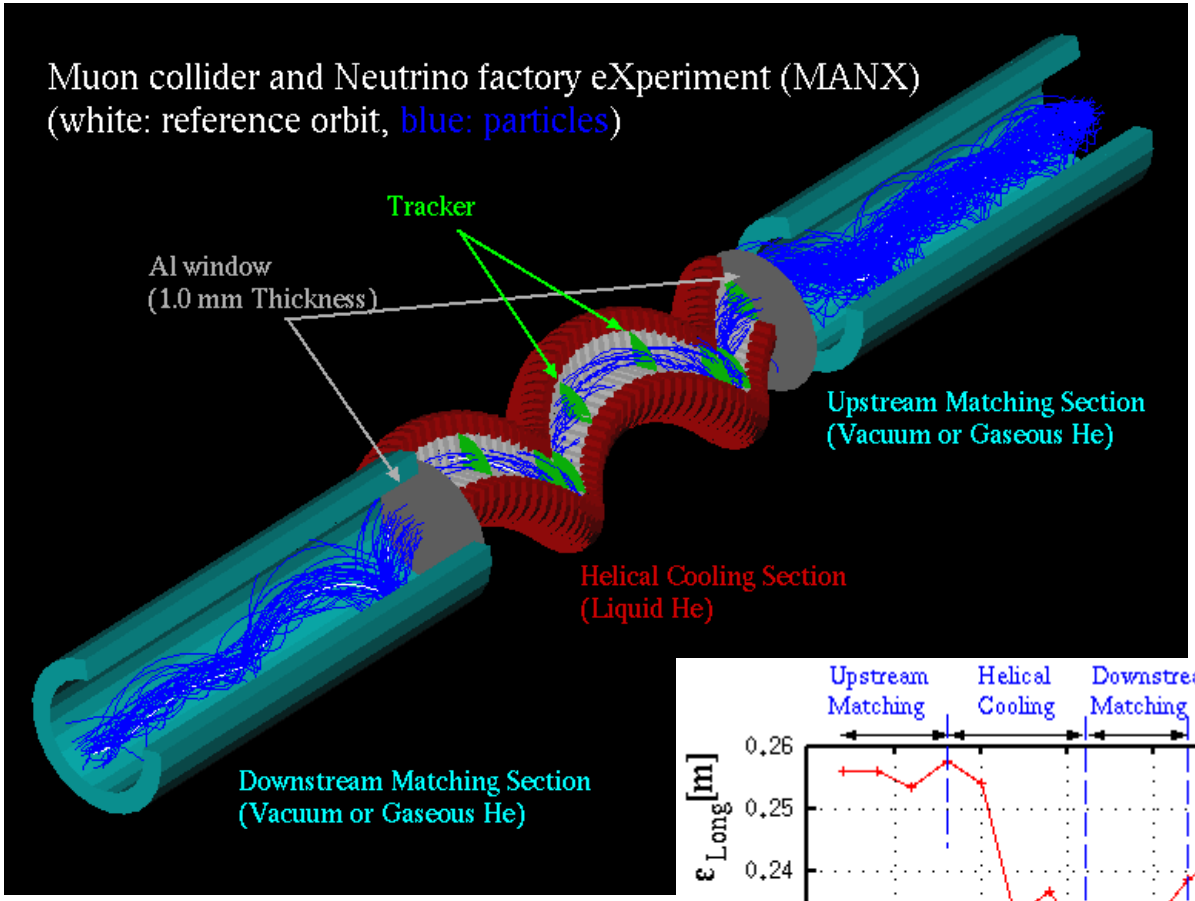
From : Pier Oddone

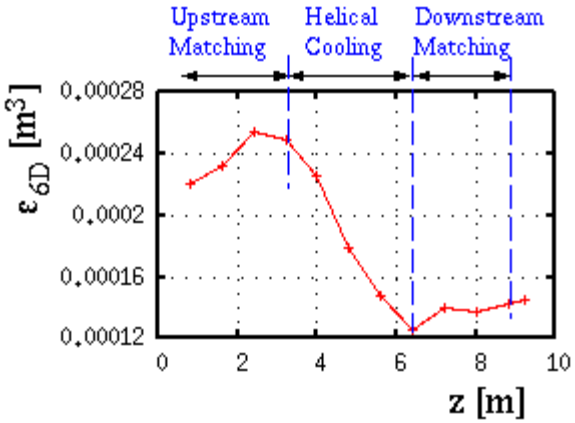
Subject: Muon Collider Task Force

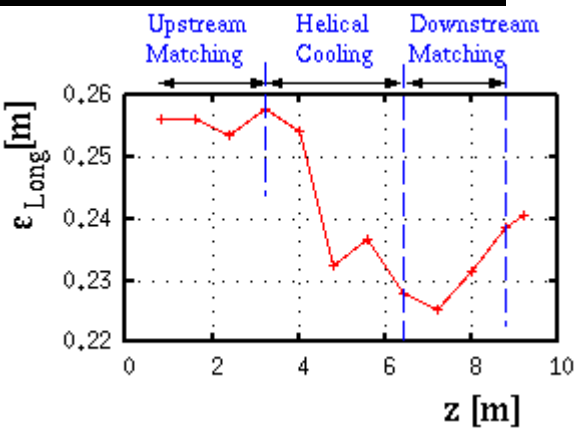
I would like to ask the two of you to form and lead a Task Force to develop a plan for an advanced R&D program aimed at the technologies required to support the long term prospects of a Muon Collider. In doing so I would ask that you operate in consideration of the attached charge, taking special note of the deliverables requested for September 2006: **A report outlining a plan for developing the Muon Collider concept based on recent ideas in the realm of ionization cooling, and an associated cooling R&D plan that can be implemented starting in FY2007. Following receipt of this report I will expect to initiate the Muon Collider study, including the associated cooling channel study and development program, in 2007.**

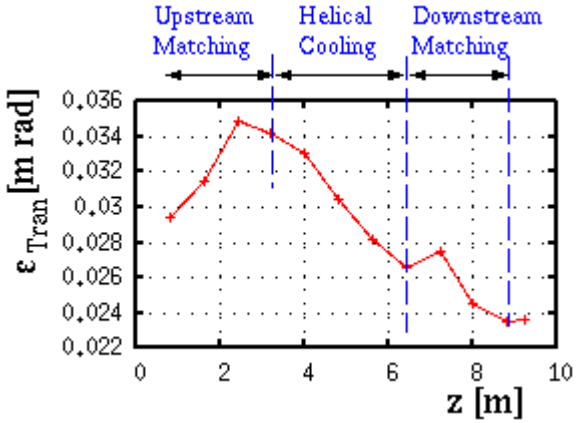
The Muon Collider represents a possible long term path for extending the energy frontier in lepton collisions beyond 1 TeV. It is important to establish the possibilities and to outline the R&D program that will be necessary to develop the underlying technology base. I look forward to working with you to formulate and execute a plan to explore these possibilities and to provide options for Fermilab and the world HEP program in the future.

Helical Cooling Channel









Muon beam cooling experiment

- Can we test this with a beam?
  - Would be complementary to MICE (single particle)!
  - Cooling of a beam would be a more tangible result than "cooling" of single particles.
  - Could potentially be done with simpler instruments (beam profiles vs tracking spectrometer).
  - Good case for doing it at Fermilab.

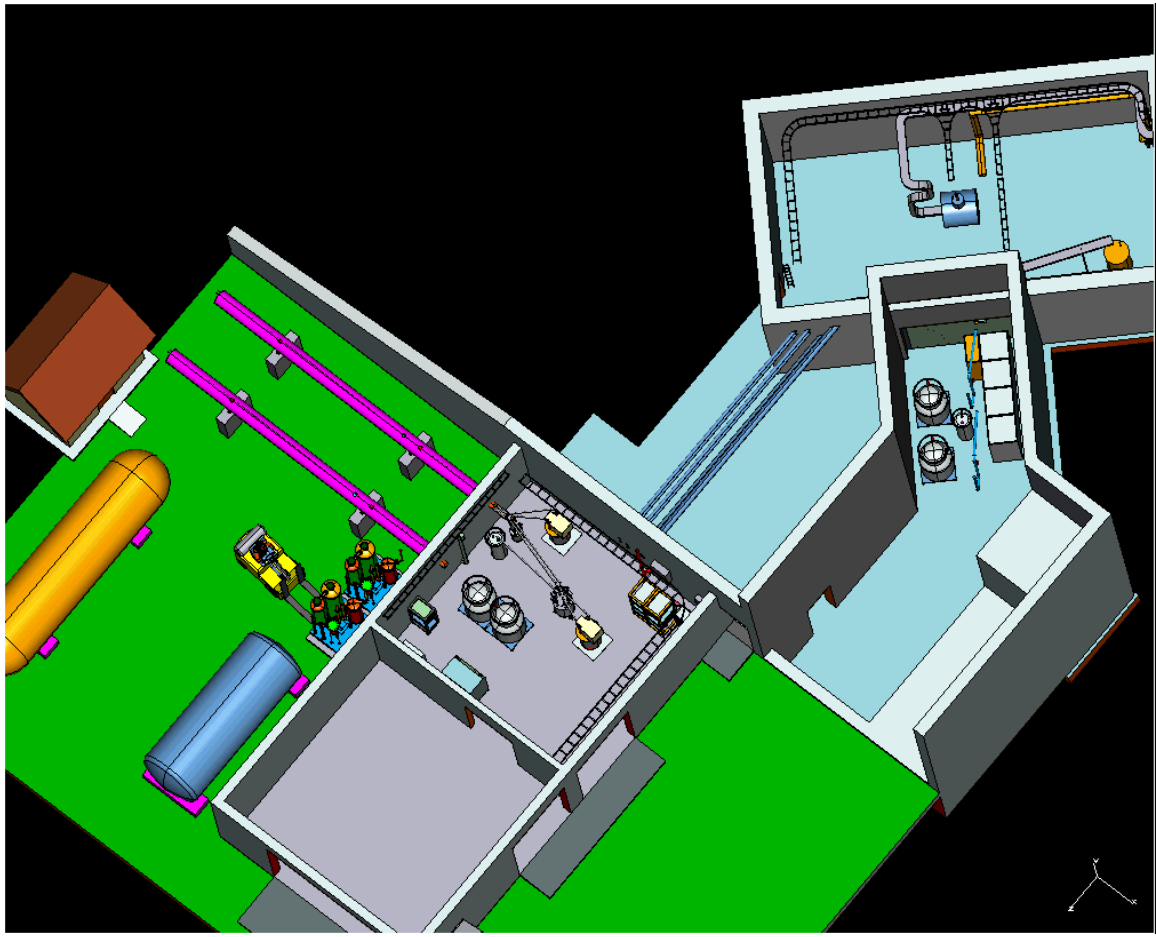
Muon beam at MTA

Close to my office

- 400MeV/c^2 protons from linac
- Relatively tight space.
- Infrastructure available (eg cryo for HCC) ☺
- High beam availability ☺
- Expect total pi+ yield few percent, usable yield of a few 10^{-5}. Could get 10^7 - 10^8 muons per pulse within the acceptance of the HCC ☺

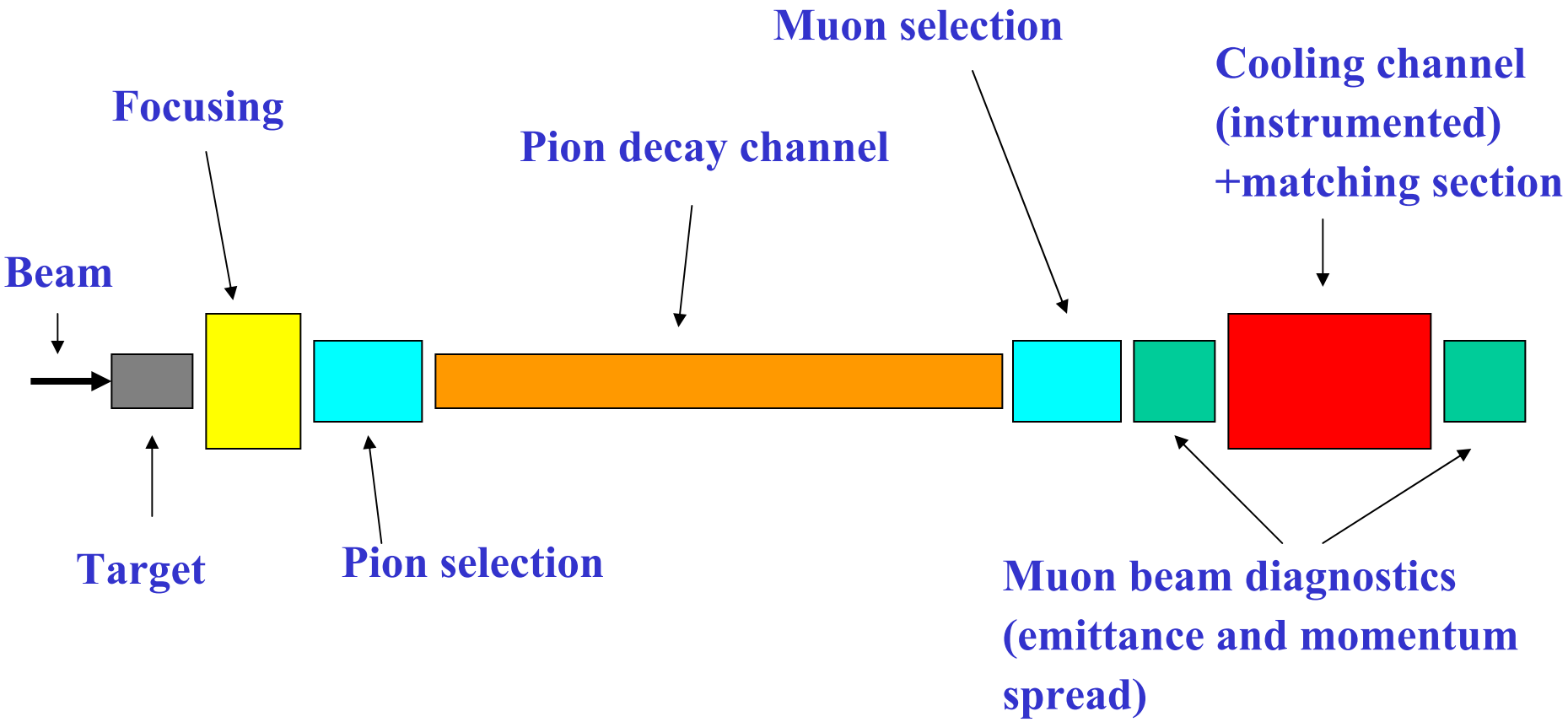
MTA

- Current R&D focus at the MTA
  - RF testing (805 and 201 MHz)
  - High pressure H_2 gas-filled RF
  - LH_2 Absorber tests
- Two parts of infrastructure yet to be completed
  - Cryo Plant
  - Beam Line
    - Low-intensity
    - High-intensity (part of MCTF)



MTA Hall

Conceptual setup



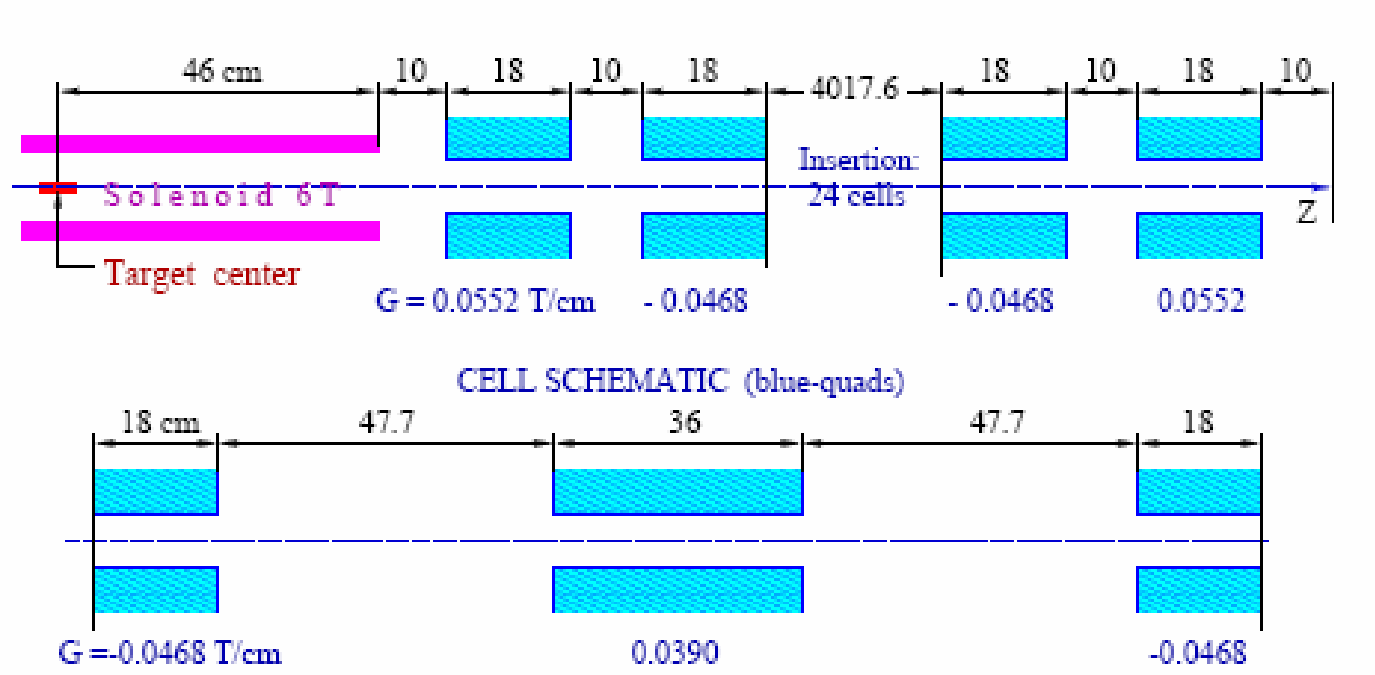
Required muon beam properties

Covariance matrix at beginning of HCC matching section:

	x	px	y	py	z	pz
x	0.00011	0.00003	0.	0.00008	0.	0.
px	0.00003	0.00008	-0.00007	0.	0.	0.
y	0.	-0.00007	0.00011	0.00003	0.	0.
py	0.00008	0.	0.00003	0.00008	0.	0.
z	0.	0.	0.	0.	0.	0.
pz	0.	0.	0.	0.	0.	0.00036

- Angular momentum is much smaller than would be generated by fringe field.
  - The beam should have canonical momentum
  - Should be generated inside a solenoid

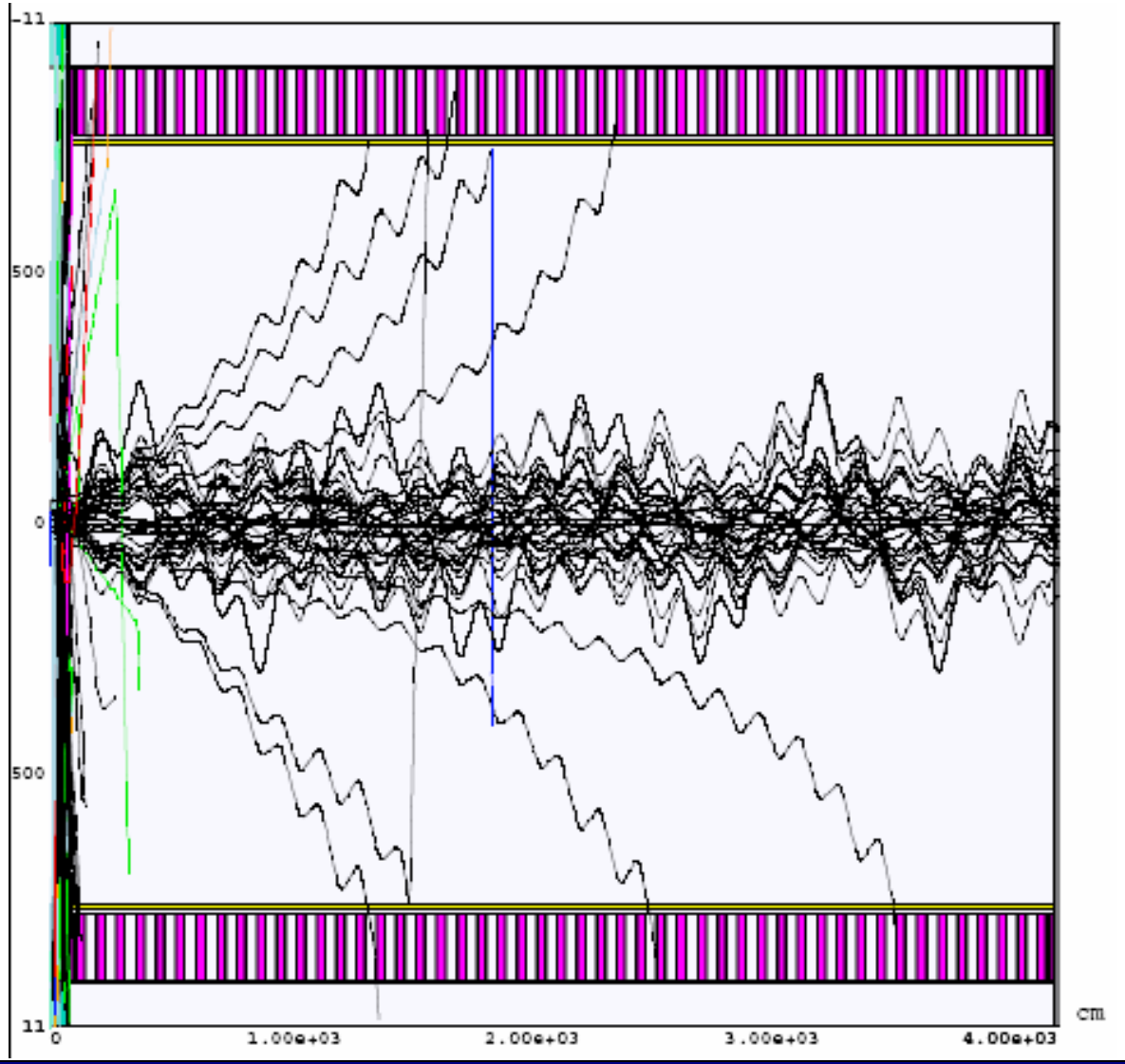
Target, pion capture and decay channel



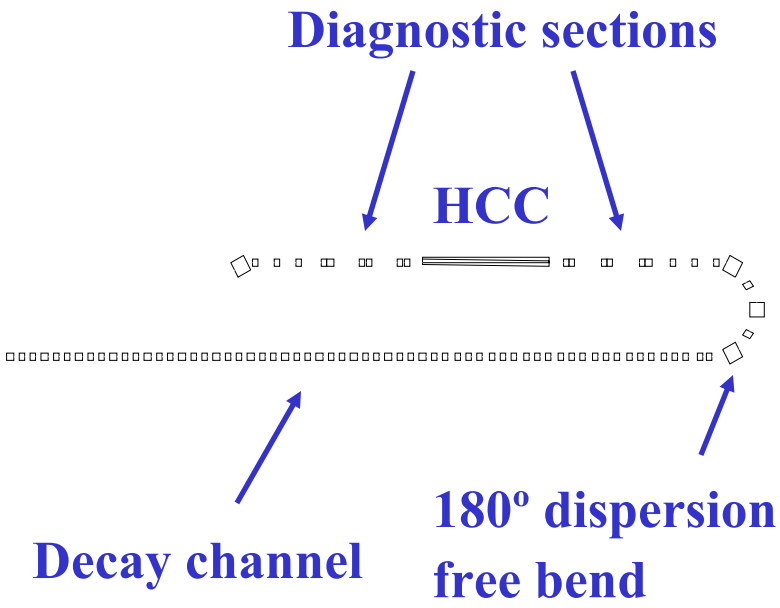
- Aluminum target in 6T solenoid.
- Quadrupole decay channel (PAC'01 design)

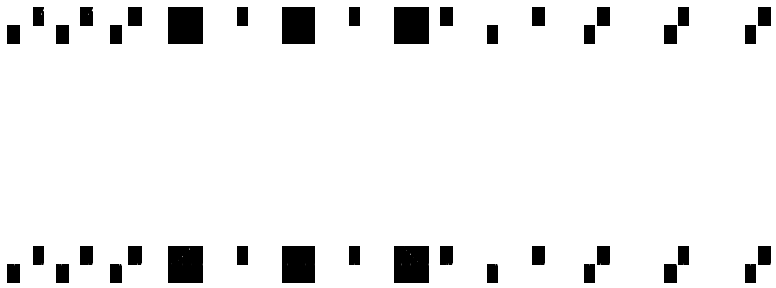
Simulation results

- MARS model of target and decay channel
- Simulations underway, expect results very soon…



Preliminary optics design



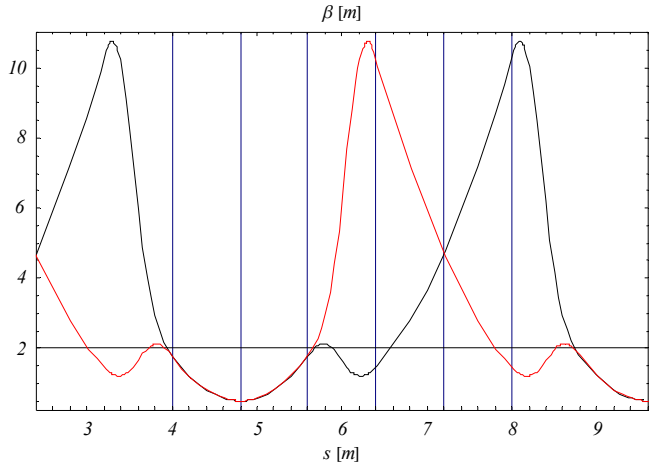


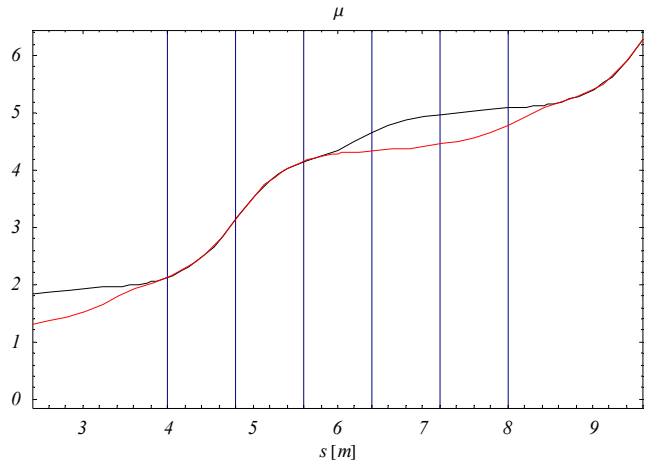
Uses BNL D2 quads

"Almost" fits in MTA

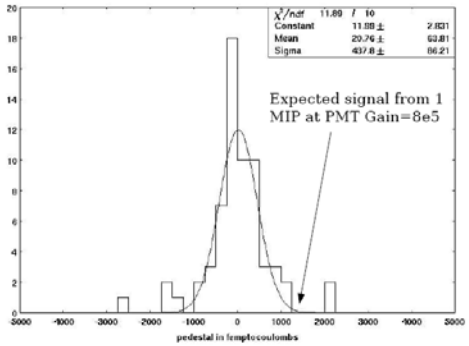
Measurement system

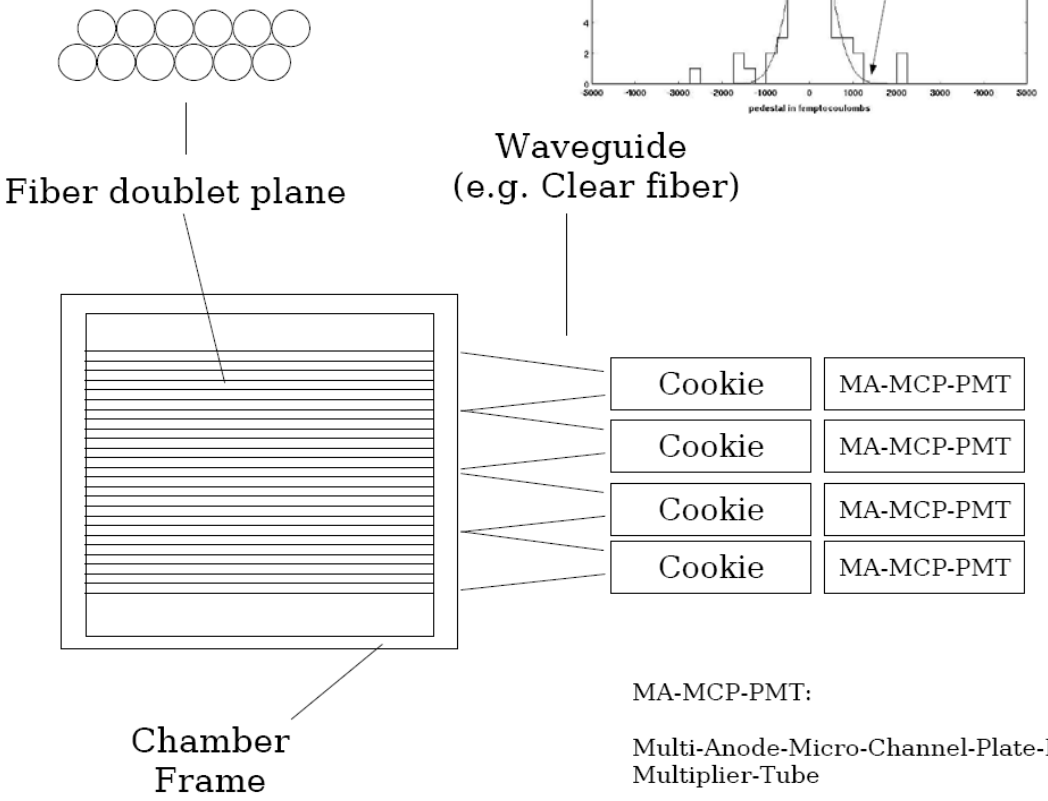
- Six profile detectors at strategic locations
- Horizontal, vertical and 45 degree profiles
- 18 data points for 12 variables (10 beam moments + 2 quad gradients)



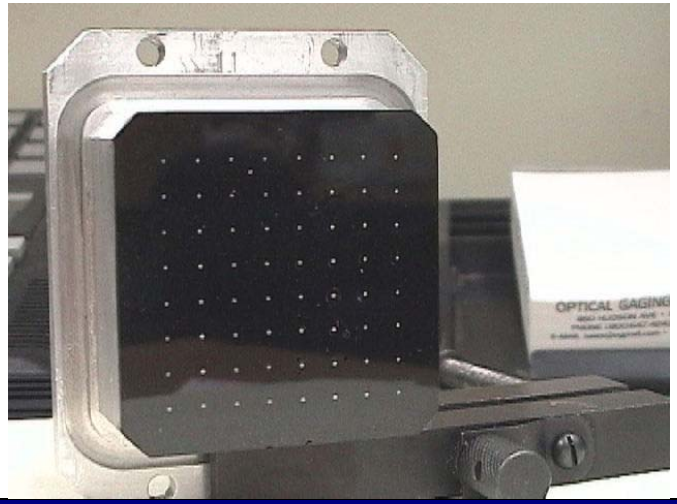


Instrumentation



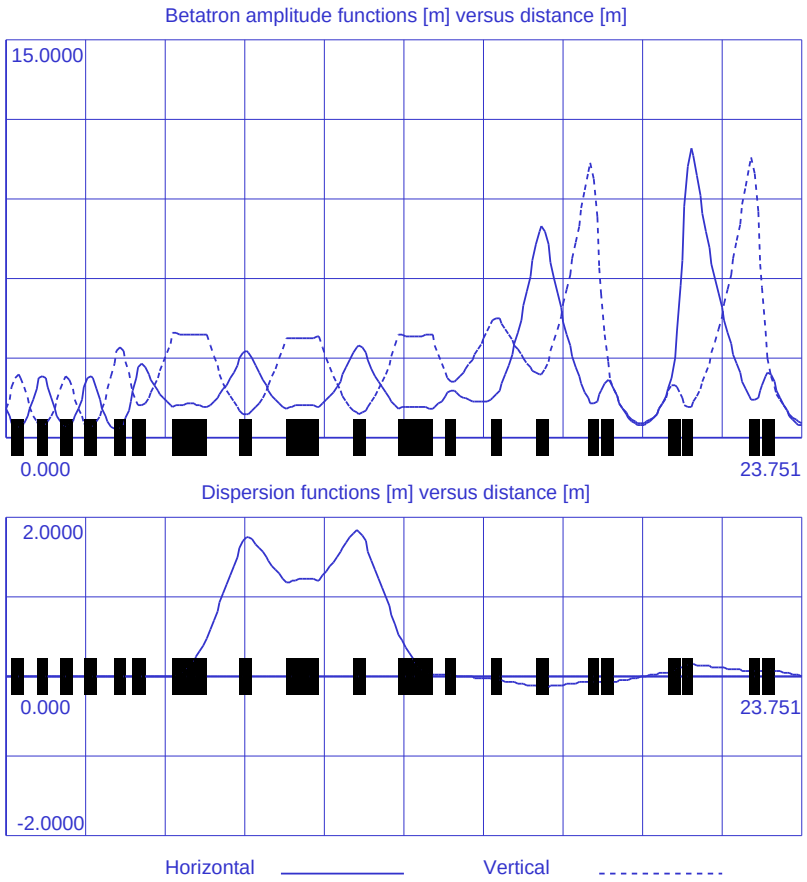


- **Fiber tracker developed by PPD for MTEST**
- **Single MIP sensitivity depending on fiber size and electronics**
- **Can probably be used directly in beam lines**
- **May be modified for use in LHe?**



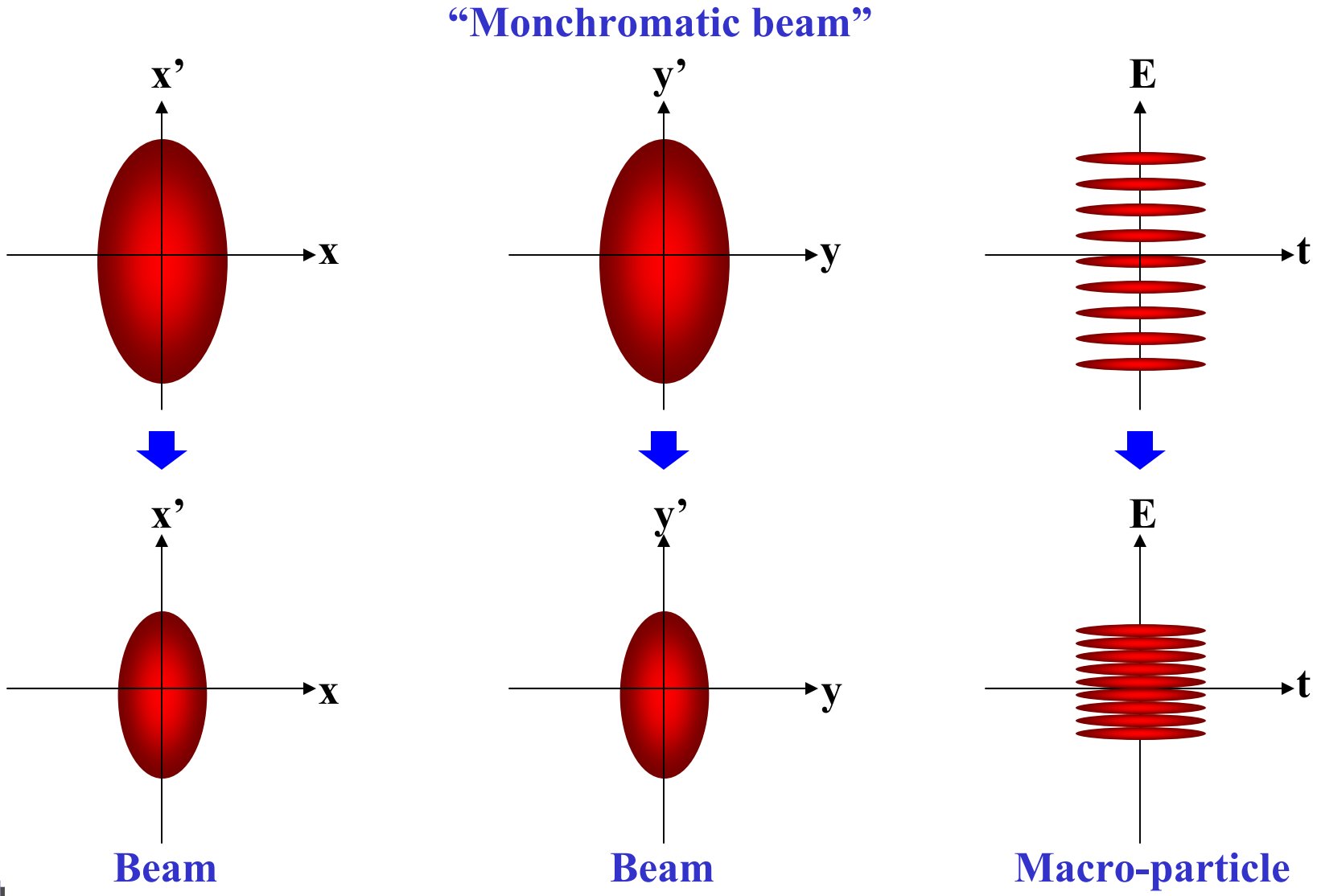
Chromaticity issue

- Chromatic effects can spoil the measurement
- Possible solution: reduce the momentum spread
- Do "macro-particle experiment" in the longitudinal plane. Only need to control and measure average momentum!
- Need to design collimation system

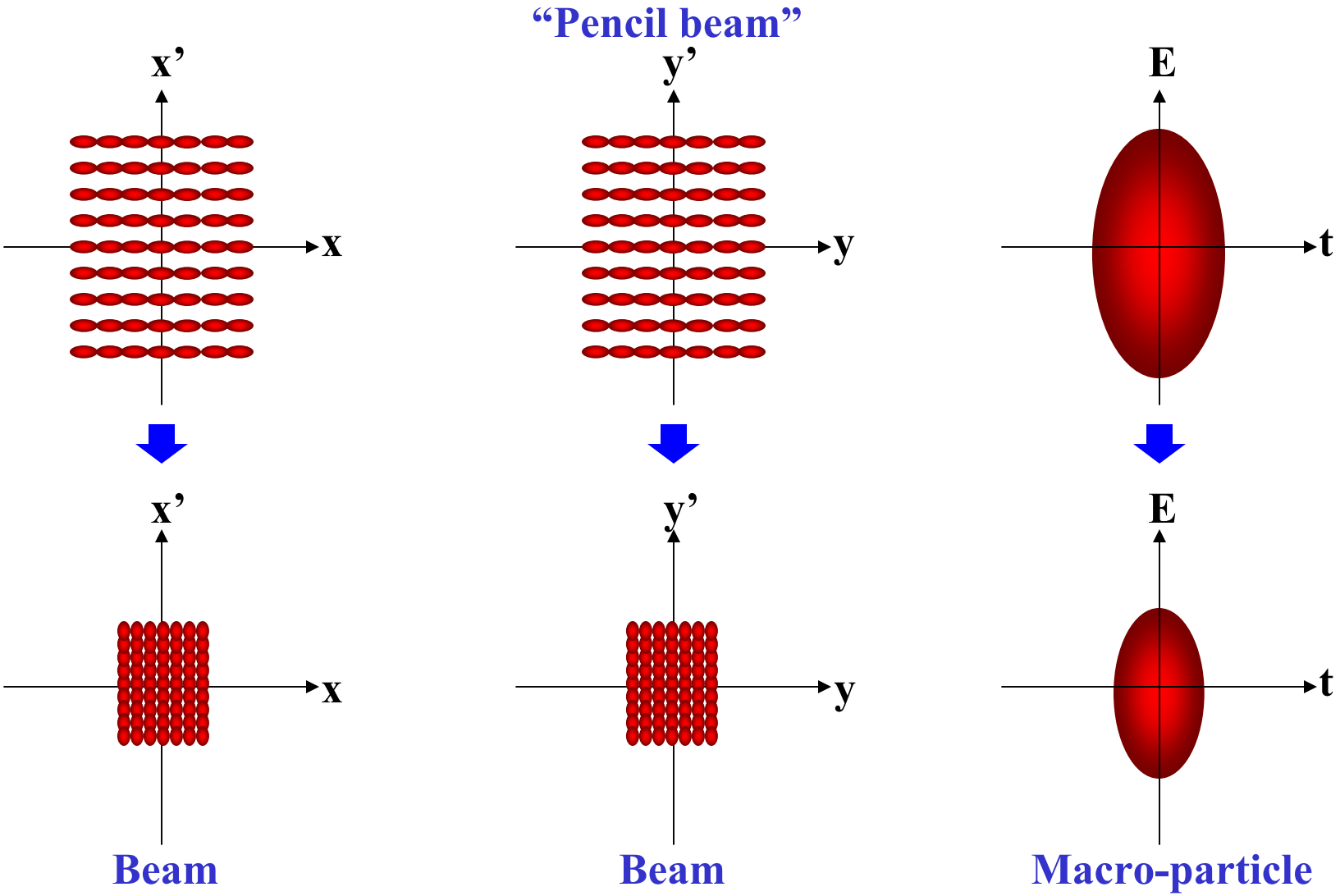


Off-momentum beta functions

Hybrid 5D Cooling Experiment



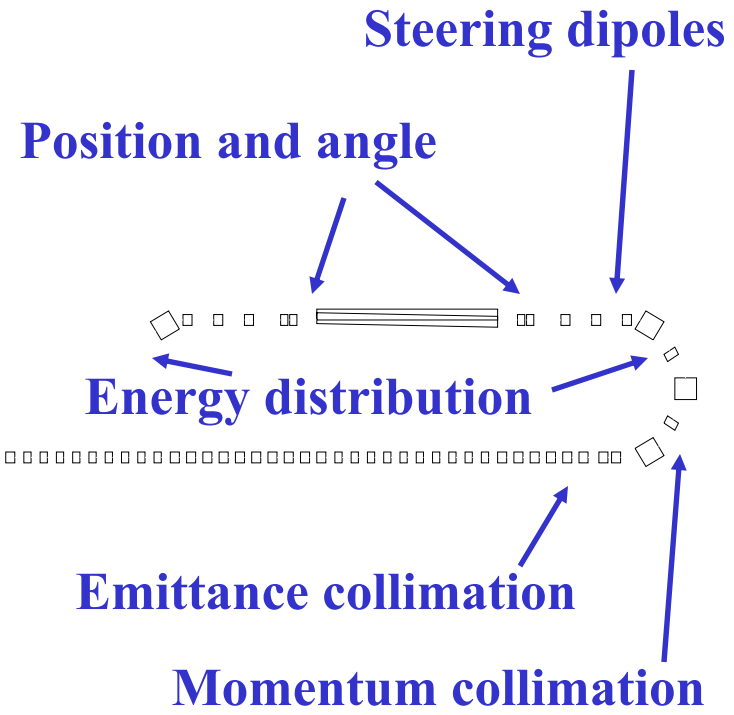
Alternate Hybrid Cooling experiment

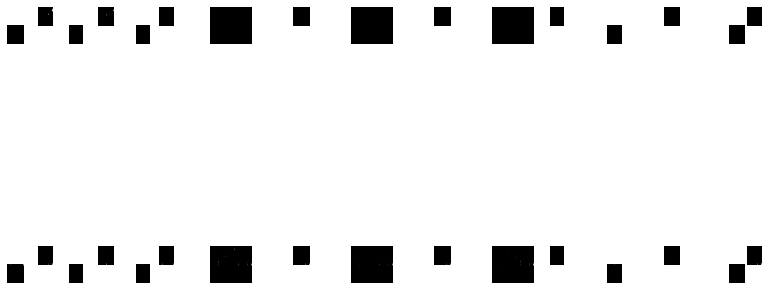


Pencil beam experiment

- Easy to generate pencil beam with large momentum spread.
- Position and angle easy to control.
- Diagnostics is simpler (mainly beam positions plus beam width in dispersive section) -> Better accuracy
- Simpler and shorter beam line.
- Can measure transverse non-linearities.

Pencil beam experiment layout





Current efforts

- Set up large scale G4BL simulation capability and refine HCC simulations.
- Simulate target and capture efficiency.
- Refine muon beamline design
- Detector development (eg SciFi in LHe)
- Coordinate with HCC design
- Think about extensions to the programme (e.g. Design and test of HCC with RF)

Conclusions

- The possibility of testing the HCC at Fermilab is being studied.
- Looks feasible to do this at MTA.
- Raster scan with pencil beam seems to be the preferred method.
- Could be relatively simple and cheap .
- More detail will be worked out over the next several months.